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THE UNIVERSITY OF ALBERTA

THE RELATIONSHIP OF CERTAIN UNDERLYING CAPACITIES TO ABILITY LEVEL IN A COMPLEX GROSS MOTOR SKILL

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS

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BY

WILLIAM WARREN MAC GILLIVARY

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APPROVAL SHEET

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Relationship of Certain Underlying Capacities to Ability Level in A Complex Gross Motor Skill," submitted by William Warren MacGillivary in partial fulfilment of the requirements for the degree of Master of Arts.

ABSTRACT

The purpose of this study was to determine the relationship of certain underlying capacities to ability level in a complex gross motor skill, namely ice hockey. The capacities investigated were total body reaction time and movement time, peripheral vision, and depth perception. Twenty-eight candidates for forward and defense positions on the 1964-65 University of Alberta hockey team served as subjects.

On the basis of the combined ratings assigned by the two independent hockey experts, the subjects were divided into a superior and an inferior group. No significant differences were found between the two groups for any of the capacities investigated.

The ability to react quickly and the speed of body movement were found to be independent and unrelated functions with the exception of choice reaction time and choice movement time.

With the exception of simple movement time, which showed a fairly high correlation with the criterion, all other correlations between the capacities and criterion were low and not significant.

Although considerable improvement was evident throughout the practice trials for both reaction time and movement time, no such significant improvement occurred throughout the simple or choice reaction time and movement time test trials.

ACKNOWLEDGEMENT

The author wishes to express his sincere appreciation and gratitude to his committee members, Dr. W. R. Morford, Dr. M. L. Howell, and Dr. W. A. Blanchard for their patience, guidance and expert criticism throughout the writing of this thesis.

A sincere vote of thanks must also be extended Mr. Clare Drake, and Mr. Ed Zemrau for their very necessary assistance in this project.

I would be remiss if I failed to mention the most necessary component for this thesis, namely the subjects who gave so willingly of their time on my behalf. A sincere thank you fellows.

Last but by no means least I must express my undying gratitude to my wife Sandra and son Sandy for their patience and sacrifice throughout these two years of graduate study.

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CHAPTER I

STATEMENT OF THE PROBLEM

It is a common assumption among coaches in the sport of ice hockey that certain psychological capacities (reaction time, depth perception, peripheral vision, etc.,) underlie success in highly skilled performance. For instance, according to Percival (95:16):

> The ability to get started quickly is something on which every hockey player ought to spend a lot of time and effort. Coaches should make quick break emphasis an important part of their practice schedule.

Similarly, another noted hockey authority has the following to say about reaction time, and the role it plays in ice hockey (104:28):

> The quick get-away is necessary to take advantage of the breaks. Getting to the puck first is a question of reaction; split seconds count in getting into top stride from a standing position.

With respect to peripheral vision and the role it plays in ice hockey, Percival says (95:106):

> Good playmakers usually have excellent peripheral vision. In other words, they have good vision to the side even when looking straight ahead. This enables them to line up a pass without giving away their intention by looking to the side.

Percival goes on to say (95:107):

> Though this type of vision is to a large degree inherited, it can be developed to an important degree through practice.

These selected statements of expert coaches are confined to the sport of ice hockey. However, similar generalized expressions of opinion are also extremely common to coaches of all types of athletic performance.

The role of basic psychological capacities as underlying factors contributing to levels of proficiency in highly skilled motor performance is frequently discussed in the literature. The most recent developments in this field being those of Fleishman (34,35,36,37,38,39,40). By and large these developments have taken place in psychology with the resultant interest being primarily concentrated on pursuit and fine coordination type tasks. The only example of a study conducted outside of psychology and related to gross muscle activity is one by Mumby (86) on kinesthetic acuity and balance correlates in wrestling ability.

A review of the literature will reveal that while a considerable body of research has to date been completed on reaction time and the role of vision in athletics, the results are equivocal and not helpful in contributing to a better understanding of whether such underlying factors do contribute to skilled athletic performance in such sports as ice hockey.

Fitts (33) has pointed out that in the absence of adequate information contributing to our better understanding of the underlying factors in skilled performance, the opinions of experts such as athletic coaches are invaluable.

Ice hockey is a game of speed and quickly changing relationships. This would appear evident at first glance. The expressions of coaching opinion in this context would also appear to be justified, although adequate scientific evidence with which to verify these relationships is still lacking. With this in mind, and with the intention of contributing to

a better understanding of the underlying factors which contribute to athletic (ice hockey) success, the present study is undertaken.

Purpose of the Study

The purpose of this study is to determine whether or not scores on total body movement time, depth perception, and peripheral vision relate to superior and inferior hockey players, when the hockey ability of the subjects is based on the averaged rankings of two independent experts according to preseason hockey performance.

Limitations of the Study

1. The subjects in this study are twenty-eight University of Alberta students who were candidates for the varsity team.

2. The method of selection of the subjects for this study; this was done by two independent hockey experts who gave the subjects a score of from 0 to 10 on general hockey ability.

3. Methods and materials employed in the study.

4. The statistical procedures used in the analysis of the data.

5. The experimental period which is of eight weeks duration, only two of which are devoted to the evaluation of the subjects.

Definition of Terms

Total body movement time. This refers to the total time elapsing between the onset of the visual stimulus and the

completion of the response. This total period of time can be further broken down into the following two phases: (a) Reaction time--the elapsed time between the onset of the stimulus and the initial response; (b) Movement time--the elapsed time between the onset of the stimulus and the completion of the response.

Depth perception. This refers to the impression of solidarity or depth of objects by combining the image of two pictures, i.e., positional relationship.

Peripheral vision. This refers to the lateral range or field of vision while looking straight ahead.

Foreperiod. This refers to the time interval between the preparatory signal and the onset of the visual stimulus.

Hockey ability. This refers to the averaged scores given to a player by two independent judges, each of whom rates the players over a two week period.

Visual stimulus. This refers to the visual signal for the subject to react, and is in the form of a bright neon light.

CHAPTER II

REVIEW OF THE LITERATURE

The review of the literature is divided into three sections.

1. Literature pertaining to reaction time and movement time.
2. Literature pertaining to peripheral vision.
3. Literature pertaining to depth perception.

Literature Pertaining to Reaction Time and Movement Time

The literature reporting on reaction time is almost unequivocal with respect to the superiority of athletes as opposed to non-athletes on measures of simple reaction time. These studies have typically reported a faster simple reaction time for athletes in general (14,15,67).

Beise and Peasley (8), in a study of the reaction time of females at various ability levels, in tennis, archery and golf, as well as general physical activity, reported that within skilled groups different levels of speed of reaction existed. This, they observed, was dependent upon the sport in which the individual was proficient. From their findings it appeared that the more active the sport, the faster the reaction time. Moreover, they reported that training in a sport for seven weeks did not materially improve reaction time.

Sigerseth and York (111) reported a significantly faster reaction time for a group of basketball players as compared to a group of non-athletes. This finding is

further substantiated in a study by Wilkinson (130) on a group of 100 athletes and non-athletes.

Olsen (90) obtained a correlation coefficient of $r = 0.398$ between simple reaction time and hockey ability ($n = 26$). In a soccer group, he reported a correlation coefficient of $r = 0.477$ between soccer ability and discriminatory reaction time ($n = 21$). He obtained an even higher correlation between baseball ability and choice reaction time ($n = 13$). For a basketball group he reported a correlation of 0.395 between basketball ability and simple reaction time ($n = 15$). However, Olsen felt that the selection of these small homogeneous samples of varsity athletes for comparison biased his data toward finding such low correlations.

Movement Time

A great deal of work has been completed on speed of movement, but little is reported on gross or total body movement.

One of the few studies in this area is reported by Burpee and Stroll (15). They studied forty-six subjects, whom they divided into four separate ability groups. According to the authors, there was a mean square contingency coefficient of $C = 0.654$ between total body movement time and participation in an athletic program. This test of total body movement time consisted of the speed with which a person could move a distance of six feet upon the presentation of a light stimulus. The small and diversified sample ($n = \frac{46}{4}$) make the results of this study difficult to evaluate.

Pfitsch (96) reported that athletes were significantly superior to non-athletes with respect to the movement of the body in response to an auditory stimulus. The findings of this study are essentially in agreement with those of Attwell and Elbel (2).

Keller (67) investigated what he called "quickness of bodily movement" and its relationship to success in athletics. He measured this trait in 636 university and high school athletes and non-athletes. The test of total body movement time or quickness of bodily movement consisted of the speed with which a person could move twenty-four inches to the left, right or forward, depending upon the direction demanded by the stimulus. From his findings, the author concluded that athletes were significantly faster than non-athletes in terms of large muscle movement time. The difference between the two groups was significant and always in favour of the athletes.

Younger (135) reported a significantly faster movement time for female athletes as compared to non-athletes. She studied forty-seven athletes and seventy-five non-athletes and reported that the reaction time and movement time scores were not correlated with coach assigned ability rankings in tennis, fencing, swimming and field hockey. Her athletic group was composed of eight tennis players, seven fencers, twelve swimmers and twenty field hockey players.

Although the correlations found were non-significant, the largest correlation in this study was between performance in the short movement (eleven inches) and fencers ($r = 0.53$). This short movement may be considered related and specific to

the fencing group more so than to any of the other athletic groups. This in itself could account for the higher correlation. Also, the small and diversified sample make the results of this study difficult to interpret.

The Relationship Between RT and MT

The ability to move the body or its parts quickly is a complex function involving neuromotor latency as well as the net motor component of the movement. The question of the degree of relationship between individual differences in the speed of reaction and the actual speed of the movement was implicitly raised by Rarick (102) in 1937 and again in 1952 by Henry (49).

Investigations have yielded somewhat variable results. Howell (57) found a significant but negative correlation of -0.38 in a situation involving special motivation (n = 50). Hipple (56) found a low positive correlation of 0.31 (N: 60), and Wilson (131) has recently reported a significant positive correlation of 0.31 (n = 50). A number of other studies have reported little or no correlation between RT and MT (33, 44, 49,50,51,72,73,102,115,116,135).

Two studies with contrary evidence are reported by Westerlund and Tuttle (129) and Pierson (99). The former investigated the relationship of reaction time to running events. They reported an extremely high positive correlation coefficient of r = 0.863. This finding is rather exceptional and has never been duplicated. The authors have given no reason for such a high relationship. It is of interest to note however, that they tested their subjects on a 75-yard

sprint, which is not a standard run for track athletes.

The second study by Pierson (99), reported a correlation coefficient of r = 0.56 between reaction time and movement time. His finding was based on a study of 400 subjects ranging in age from eight to eighty-three years. It appears that the author failed to take into account the heterogeneous age effect in arriving at his results. This point was raised by Mendryk (80), who duplicated Pierson's study, clearly showing the effect of heterogeneity of age on the size of the correlation coefficient. He reported a zero relationship between reaction time and movement time.

The general trend of these studies indicates clearly the high degree of response specificity between reaction time and movement time. In all of these studies, the reliability of individual differences for each component was very high.

Comment

The studies reviewed, while of interest have, however, added little information regarding the contribution of body or limb speed ability to superiority in athletic performance. Typically, these studies have employed simple limb movements totally unrelated to the skill under investigation. In view of recent findings reporting a high degree of movement specificity (98, 135), it would seem unwise to undertake an investigation such as the present study unless the nature of the movement is closely related to the type of skilled performance under investigation.

Also, unless such factors as motivation are adequately controlled it would seem pointless to place much value on

findings reporting differences between athletes as a group and non-athletes. The mere search for significant differences contributes little to a better understanding of the underlying factors of skilled performance. As Nunnally (88:649) stated in a recent article, "We should not feel proud when we see a psychologist smile and say, 'the correlation is significant beyond the .01 level.' Perhaps that is the most that he can say, but he has no reason to smile."

Literature Pertaining to Peripheral Vision

From extensive studies with athletes McCloy (74) has hypothesized that peripheral vision is one of a number of factors to be thought of as prerequisites to good or efficient motor learning.

Several studies are reported in the literature on the blockage of vision (66), in relation to athletic performance. These all emphasize the impairing effect of restricting normal peripheral vision but do not in fact report the relationship of individual differences in normal peripheral vision and skilled performance.

According to Winogard (132) differences do exist between successful and unsuccessful baseball players with respect to their peripheral vision. However, Patty (93) working with a group of basketball players found no significant differences between successful and unsuccessful players with respect to peripheral vision. He has attributed his findings to the fact that the unsuccessful group was allowed to wear glasses during games and in practices as well as when being tested, whereas the successful group wore glasses for reading pur-

poses, but not for games or practices. He did, however, find the successful group superior with respect to left peripheral vision.

In a recent study with basketball players, Stroup (119) reported that there was no significant difference between the mean scores for a basketball group and a non-basketball group on a field of motion perception test, (similar to total field of vision in the present study).

<u>Literature Pertaining to Depth Perception</u>

It is commonly acknowledged among coaches that the ability to see positional relationships is basic to effective performance. Meser (81) reported a relationship between visualization as determined by the Thurstone Test and correct reactions on the football field. The Thurstone Test is concerned with the ability to visualize position and positional relationships. In a game situation this would involve a player knowing at all times where he was in relation to a team-mate or an opponent. For example, the good quarterback would be able to accurately pass to his receiver a large percentage of the time.

Krestovnikov (66) reported that athletes as a group did much better on a test of depth perception (similar to Howard-Dolman apparatus) than a group of untrained controls. He reported a relationship between the athletic efficiency of tennis and soccer players and their depth perception as a group, the more skilful players perceived depth more accurately than the untrained controls.

Another Russian investigator, Skipchenko (112) found there were wide individual differences with respect to the ability to perceive depth of moving and stationary objects. There were wide individual differences in accuracy and consistency of estimates, between the moving and stationary objects.

A somewhat different approach to the problem is reported by Bannister and Blackburn (3). Measuring interpupillary distances, they found that there was a small but significant difference between rugby players and non-athletes, and it favored the rugby players. The fact that rugby players had larger interpupillary distances signified better depth perception, or stereopsis, according to the authors.

Winogard (132) hypothesized that there are differences between successful and unsuccessful athletes in depth perception. On the other hand, Patty (93) reported that for basketball players there was no significant difference between successful and unsuccessful players in depth perception. This finding is open to criticism, however, due to the test procedures that he employed.

Contrary to these findings are results reported to Clark and Warren (17) who failed to find significant differences between athletes and non-athletes on the trait of depth perception. They concluded that (17:485) ". . .either depth perception is relatively unimportant in athletics, or the instrument used did not measure depth perception accurately."

Olsen (90) investigated the relationship between depth perception and college athletic success. For a hockey group

(n = 26) he reported a Pearson-Product-Moment correlation coefficient of $r = -0.172$ between hockey ability and depth perception. He reported similar results for basketball, baseball, and soccer groups.

CHAPTER III

METHODS AND PROCEDURES

The subjects for this study were candidates for forward and defense positions on the 1964-65 University of Alberta hockey team. In all there were twenty-eight subjects. They were divided into a superior group (n = 14) and an inferior group (n = 14) on the basis of the ratings of the two independent hockey experts.

TABLE I

SOME PHYSICAL CHARACTERISTICS OF THE TWO GROUPS

Superior (n = 14)				Inferior (n = 14)			
Subject	Age Yrs.	Weight (Lbs.)	Height (Inches)	Subject	Age Yrs.	Weight (Lbs.)	Height (Inches
B. H.	21	186	73	R. C.	18	150	69
E. W.	21	150	71	G. C.	24	174	68
R. J.	22	167	70	B. E.	20	150	69
D. L.	24	167	70	W. L.	21	153	68
H. G.	26	179	69	D. Z.	20	165	71
R. H.	25	157	67	W. H.	18	180	70
E. G.	23	155	69	K. Z.	18	195	72
S. B.	19	160	70	E. M.	19	200	71
G. B.	18	180	73	D. B.	18	140	69
D. W.	24	188	70	P. T.	19	180	72
G. S.	24	155	68	J. E.	18	170	70
J. M.	20	165	71	K. G.	19	185	72
H. T.	19	170	73	G. W.	18	140	70
D. Z.	20	156	71	B. G.	19	150	70
Mean	21.9	166.1	70.4	Mean	19.2	166.6	70.1

These hockey experts, acting independently at all times, Observed the subjects in pre-season practice sessions over a

period of two weeks or ten practice sessions. Each subject was given a rating score of from 0 to 10 for each session of observation. Each of the judge's ratings were later averaged to provide a mean rank for each subject on general hockey ability. General hockey ability included skating, shooting and passing ability and a general quality referred to as "hockey sense." The entire study, after evaluation was of six weeks duration.

All subjects were tested on total body reaction time and movement time, peripheral vision, and binocular depth perception. Standard practice trials for each test item were given prior to actual testing. These trials familiarized subjects with the actual testing situation and procedure and eliminated as far as possible the factor of learning.

<u>Test Apparatus</u>

1. Howard-Dolman Device--for the measurement of binocular depth perception (see Figures 1 and II).

2. Perimeter Apparatus--for measurement of peripheral vision (see Figures III and IV).

3. Total Body Reaction Time-Movement Time Apparatus. (See Figures V, VI, VII)--This apparatus consisted of a <u>control panel</u>, a set of six-inch <u>electromagnets</u>, two <u>pick-up units</u>, three timing stations, and a stimulus panel, plus two Standard Electric 100/second chronoscopes.

The timing stations included a wooden base 2' x 3' in size, with adjustable aluminum uprights, at the top of which were horizontal bamboo rods 5' in length. Each of these bamboo rods housed a mercury switch in the end distant from the upright.

FIGURE I. Howard–Dolman Apparatus
Top View

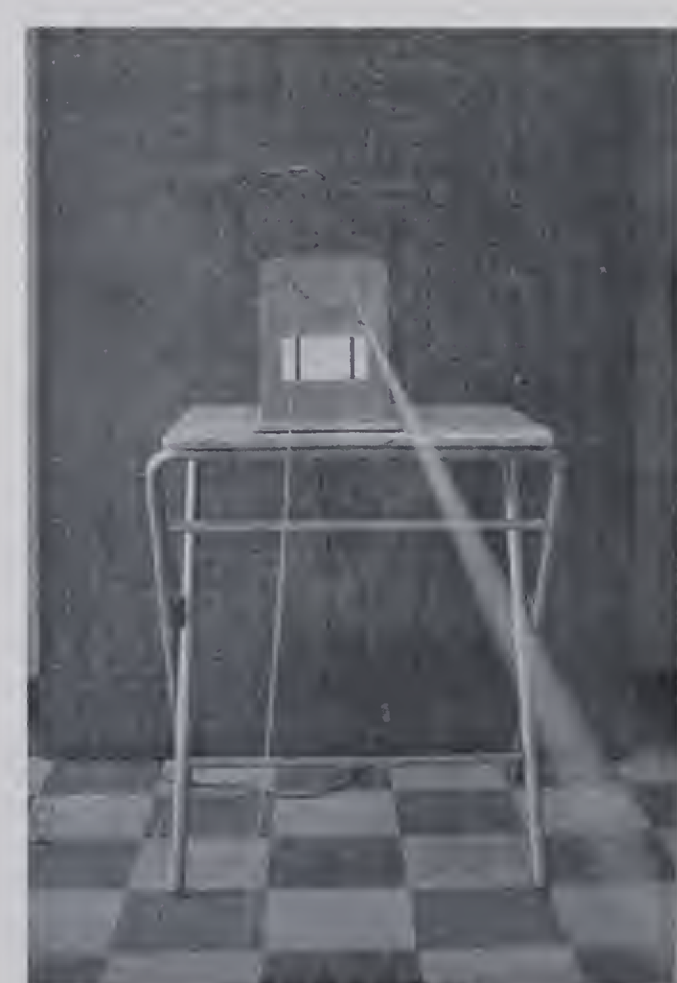

FIGURE II. Howard–Dolman Apparatus
Front View (Showing Rods
Via The Aperture At The
Front).

FIGURE III. Perimeter Apparatus.

FIGURE IV. Perimeter – Showing The Position Assumed By The Subject.

FIGURE V. Total Body Reaction Time – Movement Time Apparatus.

A. Stimulus Panel.
B. Timing Station.
C. Subject's Position
D. Experimenter's Position.

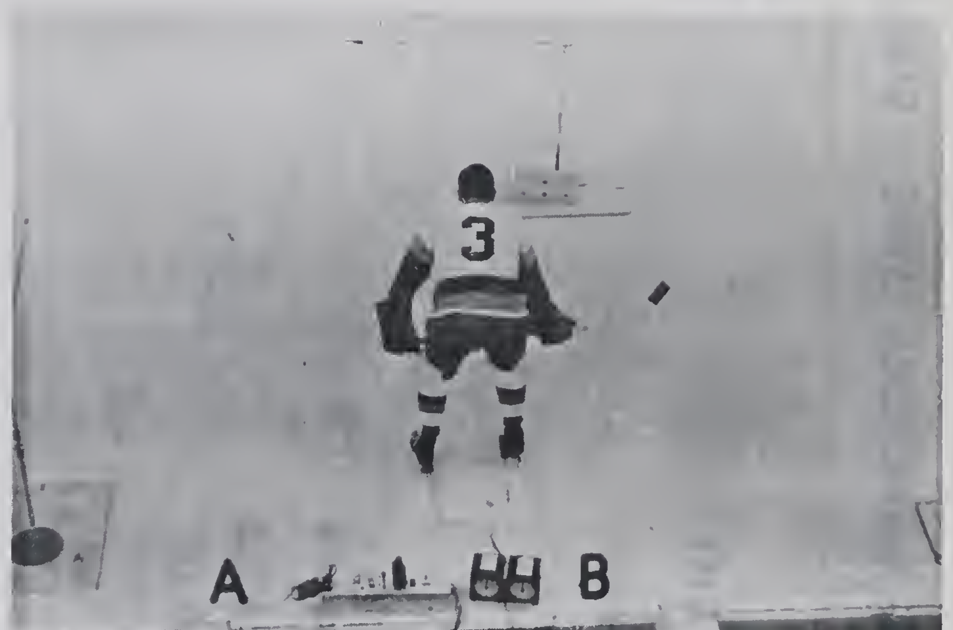

FIGURE VI. Total Body Reaction Time –Movement Time Apparatus. (From Experimenter's Position Showing ;- A. Control Console and B. Chronoscopes).

FIGURE VII. A. Stimulus Panel.
B. Timing Station.
C. Pick-Up Units.

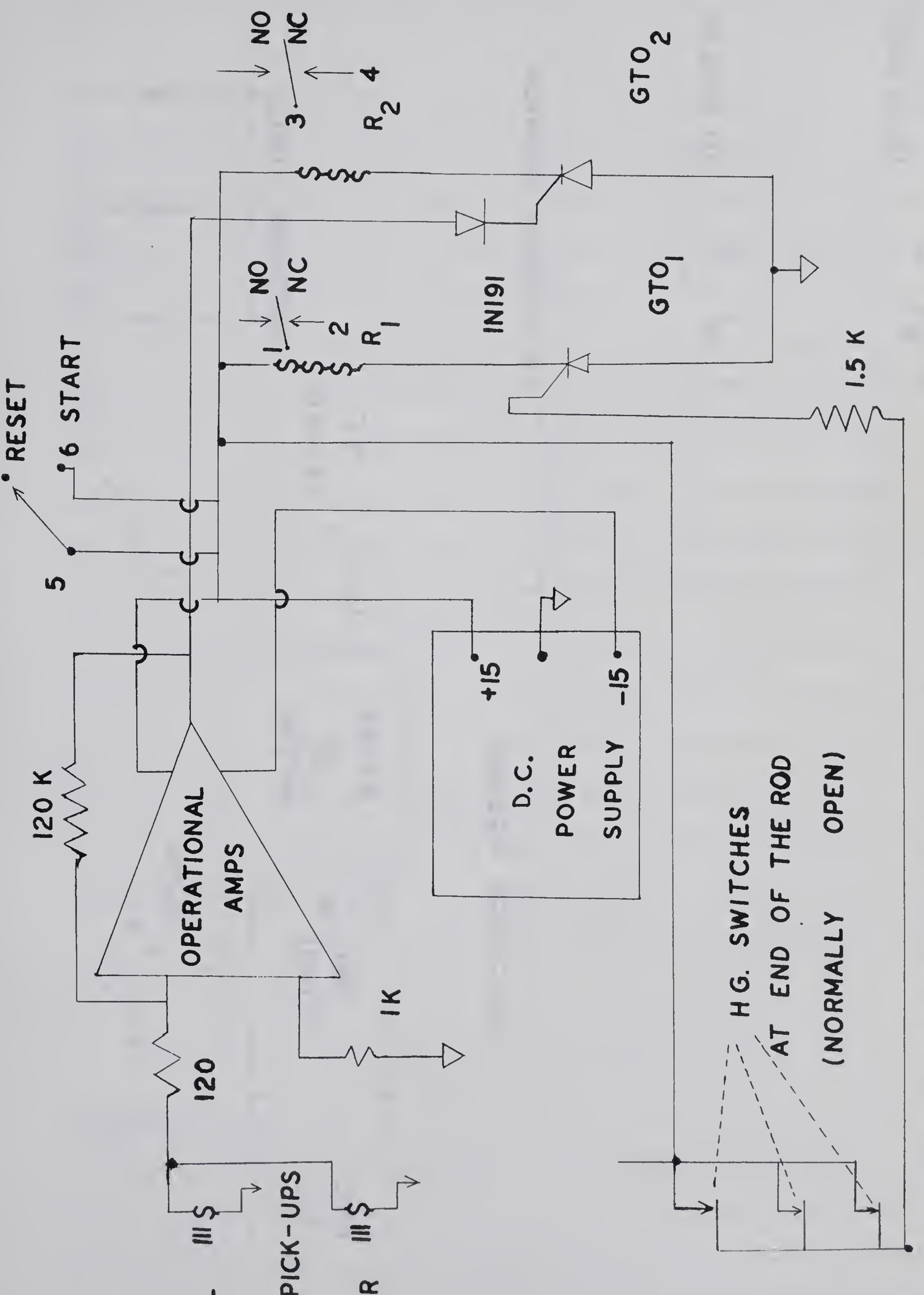

FIGURE VIII. REACTION TIME & MOVEMENT TIME CIRCUITS

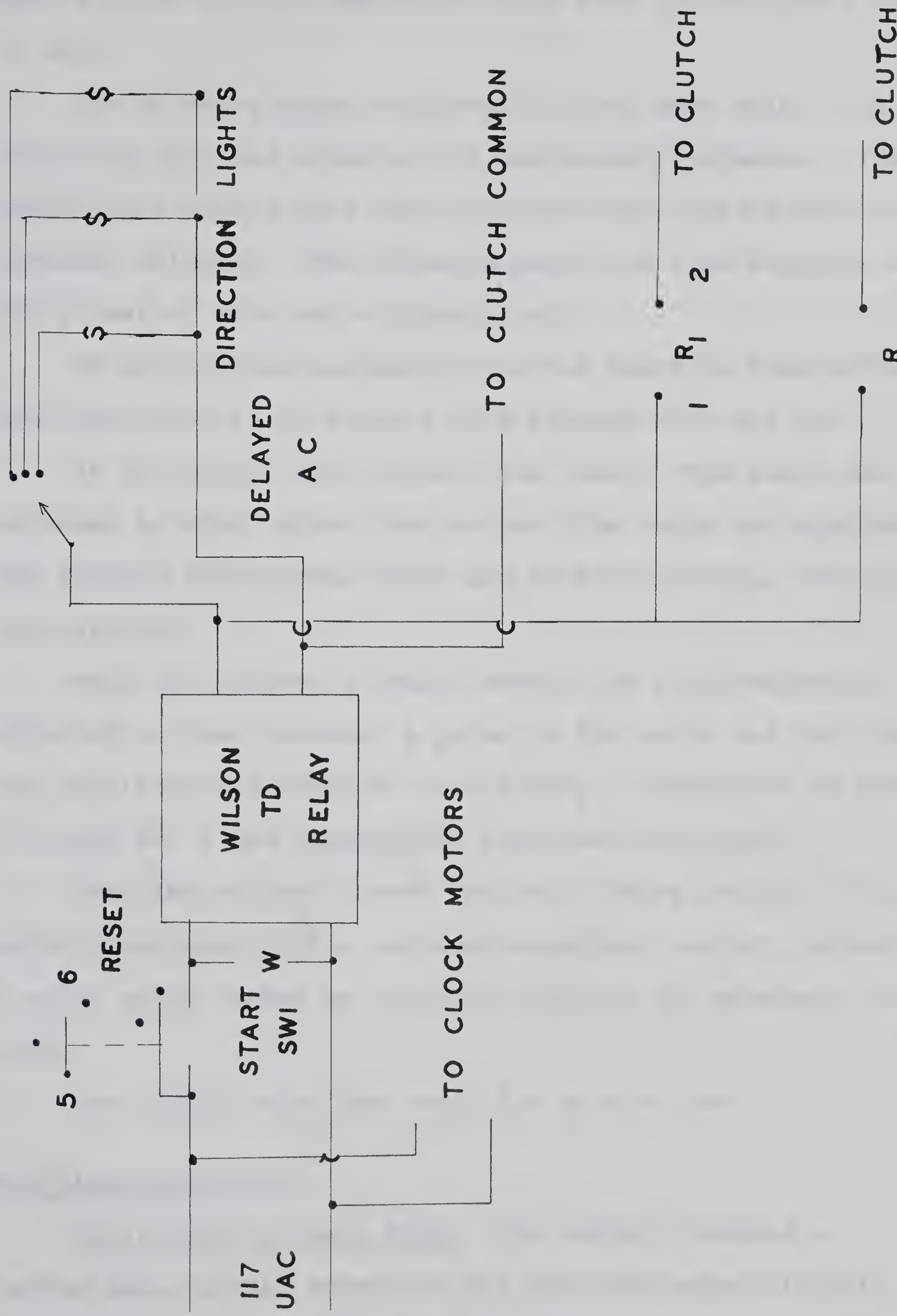

FIGURE IX. CONTROL CIRCUITS

Each station was equipped with fifty feet of wire and a plug-in unit.

The stimulus panel consisted of four neon bulbs, one of which was red, and acted as the preparatory stimulus. The other three lights were amber in color and acted as the directional stimulus. The stimulus panel was also equipped with fifty feet of wire and a plug-in unit.

An operational explanation of the Reaction Time-movement Time Apparatus is as follows (see Figures VIII and IX).

At the outset, the circuit was reset. The power was switched to start after the pre-set time delay was applied to the desired directional light and to the clutches. The clocks then started.

When the subject's skates moved, the electromagnets attached to them produced a pulse in the coils and this pulse was amplified and applied to the GTO_2. Turning it on pulled in relay No. 2 and stopped the reaction time clock.

When the subject struck the rod (timing station), the mercury switches in the rod made momentary contact, producing a pulse which turned on the GTO, stopping the movement time clock.

The circuit was then reset for another run.

Test Administration

Total Body Movement Time. The subject assumed a comfortable, normal stance on the ice with knees slightly bent and the body weight equally distributed over each foot. Two electronic pick-up units were then brought as close as

[illegible]

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[illegible]

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possible to the edges of the subject's skate blades, so as to be within inches of two electromagnets which were attached to the insteps of each skate boot. At the appearance of the stimulus light, which was preceded by the usual foreperiod of warning, the subject was required to respond as quickly as possible in one of three directions, so as to make contact with the appropriate timing station placed fifteen feet away.

Each subject completed sixty such movements following fifteen practice trials. Twenty movements were made in each direction. The direction of the first thirty test trials was randomly determined. In the last thirty trials, the subject was told beforehand in which direction he was to move. The first thirty trials simulated the defensive game situation, while the last thirty trials simulated the offensive game situation (67).

The foreperiod on these trials was varied between one and four seconds and was determined by a table of random numbers. This procedure was constant throughout the whole series of seventy-five trials.

Depth Perception. The subject was seated fifteen feet from, and in line with, the apparatus so that the rods inside the apparatus were at eye level and in plain view to the subject (Figure 2). Each subject was given several practice trials on the apparatus and was directed to manipulate the pulleys attached to the rods, so as to bring them to a position in which he perceived them to be equidistant from him (Figure 1).

Each subject was given twenty trials on this test. A single trial score consisted of the distance in centimeters that the movable rod was placed from the fixed rod, either toward (-) or away from (+) the subject. The final score was the arithmetic mean of the subject's twenty trials. Between each trial, the experimenter positioned himself between the subject and the apparatus, and set the movable rod at either the extreme front or back of the apparatus.

Peripheral Vision. The subject was seated in front of the Perimeter device and was told to fixate his eye (right or left, depending on the eye being tested) on the small mirror at the center of the device, so as to concentrate on the pupil of his own eye which was reflected in this small mirror. He was not to move his eye to either side. From outside the field of vision of the opposite eye a small white slide was moved along the horizontal arc of the perimeter. The subject was told that the moment he first saw this object in his field of vision he was to signal this verbally to the experimenter. The final position of the slide as recorded in degree units

was the measure of the subject's peripheral vision.

Each subject was given several practice trials prior to performing twenty test trials with each eye. The subject's score was the arithmetic mean of the twenty trials for each eye. The total field of vision score was determined by combining the scores for both eyes and dividing by the number of trials, giving the mean score which was taken as the final score for each subject.

TABLE 2

RESEARCH DESIGN

Day 1	15 Practice Trials 5--left, right, forward Reaction Time-Movement Time Rink	30 Trials Choice Reaction Time and movement time Rink	30 Trials Simple Reaction Time and movement time Rink
Day 2	Peripheral vision and depth perception Practice trials P.E. Lab.	20 Trials Depth perception P.E. Lab.	20 Trials left and right peripheral vision P.E.Lab.

Research Procedure

The subjects reported individually for each test session. They were first tested on total body reaction time and movement time, and these tests were conducted on the University Ice Rink. Each subject reported for the test in full hockey equipment.

The Vision tests were conducted in the motor learning laboratory of the Physical Education building and again, all

subjects were tested individually. The experimenter conducted all test sessions in both instances. Where possible, all testing was standardized.

The subjects were given the following instructions prior to the administration of each test item.

Total Body Movement Time:

". . .You will be given fifteen practice trials on this task. You are to assume a comfortable, relaxed position, with your knees slightly flexed, and the body weight equally distributed over both feet. You must try to keep the pick-up units as close as possible to the electromagnets which are attached to your skates. Please concentrate on the stimulus lights which are situated directly in front of you. The first light to appear will be the preparatory signal. Anywhere between one and four seconds after this light appears, a second light will flash. This will be the signal for you to move as fast as possible in the direction indicated to make contact with the timing station placed 15 feet from you. After completion of your practice trials, you will perform thirty trials in which you will respond to the stimulus lights only. Following these trials you will perform thirty more, in which you will be told beforehand in which direction you are to move. The only lights to appear will be the preparatory stimulus and the middle stimulus light, and with the onset of the latter, you will respond in the pre-indicated direction.

Please do not try to anticipate the direction or make any premature movements, and try to avoid any exaggerated body

patients were tested individually. The [illegible] all test sessions [illegible] was standardized.

The subjects were given the following instructions prior to the administration of each test.

[illegible]

[illegible] you will be given [illegible] [illegible] [illegible] which is close [illegible] [illegible] lights which are [illegible] [illegible] [illegible] [illegible] [illegible] direction.

Please do not try to [illegible] [illegible]

lean when coming in contact with the timing stations. You must be conscious of skating through these stations, and not with just making contact with them."

Depth Perception:

". . .You will sit directly in line with the apparatus, and in a position which allows you to see the two rods via the aperture at the front of the apparatus. By manipulating the strings attached to the rods, you will attempt to adjust the rods to a position which you feel places them equidistant from one another. You will be given four practice trials. Between each trial, you will release the strings while the rods are reset. You will perform twenty trials on this task."

Peripheral Vision:

". . .You will position yourself so that your eye is resting against the eye-rest at the center of the perimeter. Now fixate your eye on the mirror in the center of the horizontal arc of the perimeter. Looking into this mirror you will see the pupil of your eye. Concentrate on this, and do not move your eye in any direction. A white centered slide will be brought into your field of vision, and when you pick this up in your lateral field, signify this to the experimenter.

You will perform twenty trials with both the left and right eyes. You will be given four practice trials on this task."

Statistical Procedures

Reliabilities for all measurements were determined by the odd-even method. They were corrected for full test length by means of the Spearman-Brown Prophecy formula (30:179).

The relationship between the criterion and the psychological capacities being measured was determined by means of the Pearson-Product-Moment Correlation coefficient (30:91).

In order to determine the difference between the superior and inferior hockey groups. their performance was compared by means of a test (30:143).

The relationship between all variables was determined by the Pearson-Product-Moment correlation method. A multiple correlation technique (30:288) was applied to the correlations in order to maximize the correlation between the capacities under investigation (predictors) and the criterion (ratings).

The significance of the difference between selected trial intervals for reaction time and movement time for trials 1-3 versus 13-15, trials 16-18 versus 43-45, and trials 46-48 versus trials 73-75 were determined by means of a t ratio for significance of differences between two means for correlated samples (30:138).

CHAPTER IV

RESULTS AND DISCUSSION

Results

The reliability coefficients for performance in each of the measures of reaction time, movement time, peripheral vision and depth perception were computed as the correlation between the odd-even numbered trials of each test item. The uncorrected (half-length test) reliability coefficients are given in Table 3 along with the corrected, full test coefficients. It can be seen that all of these reliability coefficients are fairly high. The lowest was for simple reaction time, r = .796; corrected for full test length by the Spearman-Brown Prophecy formula this becomes r = .886. These coefficients indicate clearly the existence of highly reliable individual differences in each of the variables tested.

TABLE 3

ODD-EVEN RELIABILITY COEFFICIENTS

Measures	Half-Test Reliability	Corrected
Simple Reaction time	.796	.886
Simple movement time	.810	.895
Choice reaction time	.857	.923
Choice movement time	.815	.898
Left peripheral vision	.939	.968
Right peripheral vision	.941	.969
Total field of vision	.955	.977
Depth perception	.893	.943

The criterion (hockey ability) was determined as mentioned previously by the independent ratings of two hockey experts. The Pearson-Product-Moment correlation coefficient between these ratings was r = 0.79. Corrected by the Spearman-Brown method the reliability of the combined ratings becomes r = 0.88.

TABLE 4

MEANS, STANDARD DEVIATIONS, AND RANGE OF OBSERVATIONS FOR RT, MT, PERIPHERAL VISION AND DEPTH PERCEPTION (N : = 28)

Variable	Units	Mean	SD	Range
Simple reaction time	seconds	0.395	0.063	.300 - .560
Simple movement time	"	1.710	0.058	1.542 - 1.866
Choice reaction time	"	0.439	0.080	.332 - .657
Choice movement time	"	1.788	0.057	1.609 - 1.914
Left peripheral vision	degrees	87.800	1.780	81.800 - 90.000
Right peripheral vision	"	86.700	2.200	81.400 - 89.800
Total field vision	"	174.500	3.830	163.600 -179.200
Depth perception	centi-meters	1.693	1.077	.410 - 4.530

The reaction times and movement times treated as single measures rather than as separate phases (i.e., right, left, and forward). The mean simple (offensive) reaction time was .395 seconds, with a range of .300 to .560 seconds and a standard deviation of .063 seconds. The mean choice (defensive) reaction time was .439 seconds with a range of .332 to .657 seconds and a standard deviation of .080 seconds.

The mean simple movement time was 1.710 seconds with a range of 1.542 seconds to 1.866 seconds and a standard deviation of .058 seconds. In the choice movement time trials, the mean was 1.778 seconds with a range of 1.609 seconds to 1.914 seconds and

a standard deviation of .057 seconds.

The peripheral vision measure was subdivided into left, right, and total field of vision aspects. The mean for left peripheral vision was 87.8 degrees, with a range of 81.8 degrees to 90.0 degrees, and a standard deviation of 1.78 degrees. The right peripheral vision mean was 86.7 degrees, with a range of 81.4 degrees to 89.8 degrees and a standard deviation of 2.20 degrees. The mean score for the group for the total field of vision was 174.5 degrees, with a range of 163.6 degrees to 179.2 degrees and a standard deviation of 3.83 degrees.

The mean score for the group on binocular depth perception was 1.693 centimeters with a range of .410 centimeters to 4.530 centimeters, and a standard deviation of 1.077 centimeters. These results appear in Table 4.

Correlation Analysis

The Pearson-Product-Moment correlation coefficients between simple and choice reaction time measures and the ratings of the two hockey experts on hockey ability (criterion) failed to reach significance at the five per cent level of confidence. The further breakdown of the reaction time phase into its directional aspects (i.e., right, left, and forward) also failed to show any appreciable relationship with the judges' ratings.

With respect to the movement time phase of this study, simple movement time and judges' ratings showed a correlation coefficient of $r = 0.48$ which is significant at the five per cent level. The right directional aspect showed a correlation coefficient of $r = 0.493$ with the ratings while the forward aspect showed a correlation coefficient of $r = 0.459$. Both were also significant at the five per cent level of confidence.

No significant relationship was found between choice movement time and the ratings of the judges, although the choice movement time to the right alone showed a correlation of r = 0.433 with the criterion, which is significant at the five per cent level.

The Pearson-Product-Moment correlation coefficients between peripheral vision and the criterion were non-significant. This was true for left, right, and total field of vision, as well as for depth perception. These results are summarized in Table 5.

TABLE 5

COEFFICIENTS OF CORRELATION BETWEEN CRITERION AND PSYCHOLOGICAL CAPACITIES (n = 28)

	Correlation Coefficient	Corrected for Attentuation
Simple reaction time	0.175	0.198
Choice reaction time	0.295	0.327
Simple movement time	0.484	0.545
Choice movement time	0.287	0.323
Left peripheral vision	0.294	0.319
Right peripheral vision	0.169	0.183
Total field of vision	0.235	0.253
Depth perception	-0.067	-0.074

r= .374 for significance at five per cent level.

Multiple Correlation Analysis

It is apparent that in all cases the relationship between the independent variables (simple movement time, choice movement time, peripheral vision and depth perception) and the criterion, are low. The highest was only r = 0.48 for simple movement time and the criterion, indicating that only 23 per cent of the variance

in one variable is accounted for by variance in the second variable.

When these variables were taken together and subjected to a multiple correlation analysis (30:301), their total predictive value was still low and non-significant(($R_1(2,3,4,5) = .59$).

Pearson-Product-Moment correlation coefficients between the variables under investigation showed several significant correlation coefficients. Notable among these were the relationships between simple and choice reaction time (r = 0.82); between choice reaction time and simple movement time (r = 0.58) and choice movement time and simple movement time (r = 0.89). The relationship between left and right peripheral vision was also significant at the .05 level (r = 0.76).

These and other correlation coefficients are summarized in the intercorrelation matrix of Table 6.

TABLE 6

INTERCORRELATIONS BETWEEN RT, MT, PERIPHERAL VISION AND DEPTH PERCEPTION (N = 28)

	2	3	4	5	6	7	8
	.363	.820	.275	-.130	.030	.087	.002
Simple RT		.582	.890	.192	.373	.133	.119
Simple MT			.438	.131	.109	.140	.008
Choice RT				.031	-.025	-.044	.111
Choice MT					-.078	-.249	-.145
Left peripheral vision						.756	-.289
Right peripheral vision							-.133
Total field of vision							
Depth perception							

r must exceed .374 for significance at .05 level.

Differences Between the Superior and Inferior Groups on Psychological Capacities Investigated

The subjects were separated into a superior and an inferior group. The superior group was composed of the top fourteen subjects, based on the combined rankings of the two hockey experts, while the inferior consisted of the lower or bottom fourteen subjects after ratings were completed.

No significant difference was found between the groups on choice reaction time, simple reaction time, simple or choice movement time, peripheral vision or depth perception. These data are summarized in Table 7.

TABLE 7

DIFFERENCES BETWEEN MEANS OF SUPERIOR AND INFERIOR GROUPS FOR RT, MT, PERIPHERAL VISION, AND DEPTH PERCEPTION

Variable	Units	Superior		Inferior			
		Mean	S.D.	Mean	S.D.	Diff.	t
Simple MT	Seconds	1.682	0.056	1.739	0.061	.057	1.82
Simple RT	"	0.390	0.051	0.400	0.074	.010	0.34
Choice MT	"	1.763	0.058	1.797	0.056	.034	0.96
Choice RT	"	0.420	0.049	0.458	0.102	.038	1.26
L. Peripheral vision	Degrees	87.200	1.900	88.400	1.640	1.200	0.81
R. Peripheral vision	"	86.400	1.970	87.100	2.400	0.070	0.71
Total field of vision	"	173.500	3.750	175.500	3.900	2.000	0.88
Depth perception	Centi.	1.920	1.125	1.480	1.032	0.440	0.74

With N = 28, t is required to reach 2.06 for significance at five per cent level.

In addition to the above findings the difference between the superior and inferior groups on left simple movement time was significant at the five per cent level, the t for this difference being 2.08. None of the other directional aspects showed significant differences for either RT. or MT. between the two groups.

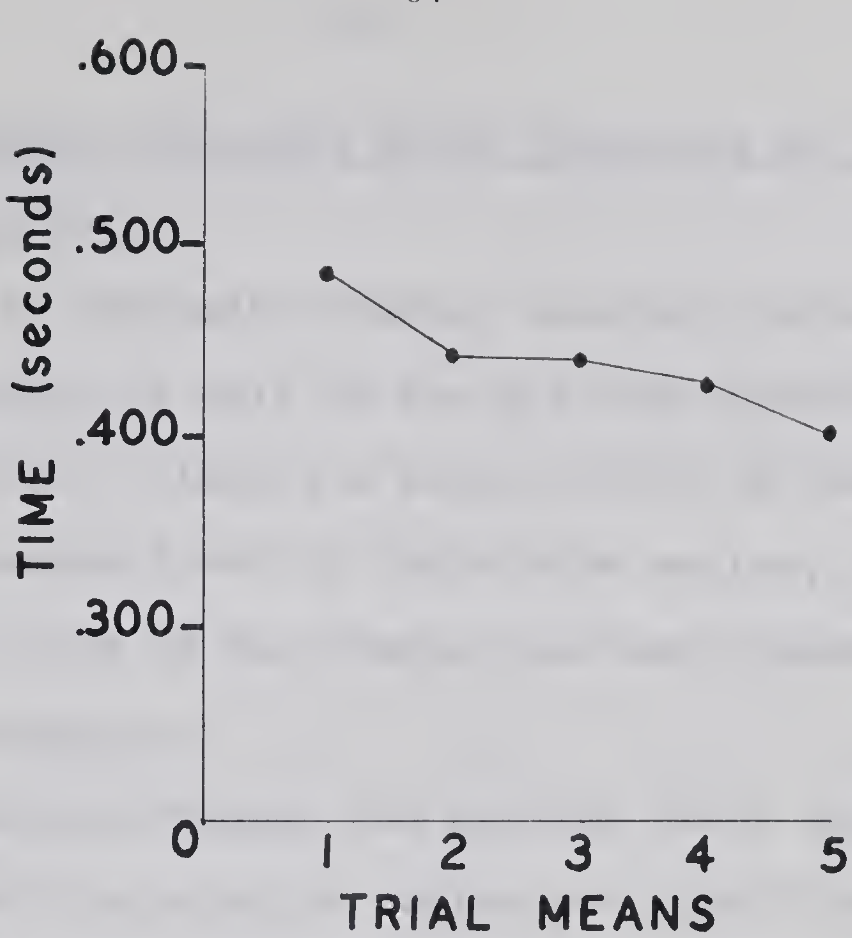

FIGURE X. Reaction Time Scores For Trials 1–15. Each Trial Mean In The Figure Represents The Mean Score For Left, Right and Forward Measures Combined.

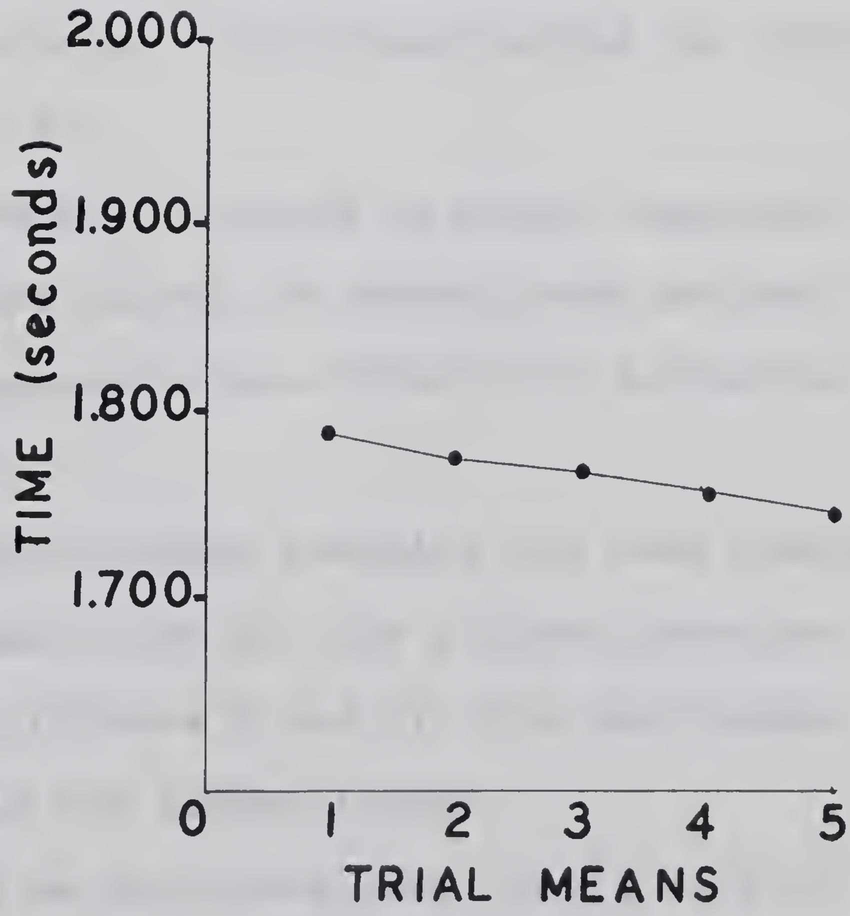

FIGURE XI. Movement Time Scores For Trials 1–15. Each Trial Mean In The Figure Represents The Mean Score For Left, Right And Forward Measures Combined.

<u>Differences Between Selected Trial Intervals for Reaction Time and Movement Time</u>

In order to determine whether learning occurred during the actual test period as well as the pre-test practice trials, the averaged means for trials 1-3 versus 13-15 of the practice series, trials 16-18 versus 43-45 of the choice series, and trials 46-48 versus trials 73-75 of the simple reaction time-movement time series, were compared.

The difference between the initial (1-3) and final (13-15) three trials of the practice series was significant beyond the five per cent level (t = 3.04).

With respect to movement time, there was a significant difference between the initial score (mean of trials 1-3) and the final score (mean of trials 13-15) of the practice series, the difference being significant beyond the five per cent level as well (t = 3.47).

No improvement occurred in either reaction time or movement time performance during the actual test period, either during the choice response trials (16-45) or during the simple response trials (46-75).

The extent to which learning did take place in both reaction time and movement time for the fifteen practice trials is illustrated by Figures X and XI. The improvement over these practice trials was almost linear.

It should be mentioned that trials 1-45 were all of the choice response nature, while trials 46-75 were of the simple response type. As stated previously, the choice situation simulated the defensive game situation, whereas the simple response

simulated the offensive game situation.

These results are summarized in Table 8.

TABLE 8

DIFFERENCE BETWEEN SELECTED TRIAL INTERVALS FOR REACTION TIME AND MOVEMENT TIME

Variable	Mean	S.D.	Mean	S.D.	D	t
			Trials 1-3 versus 13-15			
Reaction time	0.492	0.154	0.406	0.068	0.086	3.04[a]
Movement time	1.799	0.077	1.748	0.069	0.051	3.47[a]
			Trials 16-18 versus 43-45			
Reaction time	.428	0.141	.425	0.083	.003	0.63
Movement time	1.766	0.069	1.785	0.071	.019	1.83
			Trials 46-48 versus 73-75			
Reaction time	.413	0.097	.386	0.117	.027	1.26
Movement time	1.698	0.071	1.709	0.071	.011	1.02

[a]t must be 2.06 for significance at the five per cent level of confidence.

S.D. - Standard Deviation

D - Difference.

Discussion

The reliability coefficients for performance on each of the reaction time, movement time, depth perception and peripheral vision tests were high and quite adequate in each case, similarly the correlation between the ratings of the hockey experts.

The tests of reaction time and movement time employed in the present study were rather novel, and for this reason comparisons cannot be drawn with other studies on reaction time and movement time. Typically, in these studies, adequate reliability of individual differences was established on the basis of at least thirty trials.

The test of depth perception employed in this study has been used in previous studies. Both Imus (61) and Warren (128) reported a figure of $r = 0.89$ for ten trials. Converting this figure to an estimated reliability based on twenty trials results in a coefficient of $r = 0.94$ which is essentially the figure obtained in the present study.

The relationship of the independent variables (reaction time, movement time, peripheral vision, and depth perception) to the criterion were negligible in each case with the exception of the criterion versus simple movement time ($r = 0.48$) which was significant but low. When corrected for attenuation this became $r = 0.55$ which, while significant, is not a large correlation. The other correlation coefficients were all low and ranged from $r = -.07$ for depth perception to $r = 0.30$ for choice reaction time in relation to the criterion.

These findings are consistent with those reported by Olsen (90), who obtained a correlation coefficient of $r = -0.172$

between depth perception and hockey ability, and a correlation coefficient of r = 0.40 between simple reaction time and hockey ability. His measures of reaction time and movement time were of a much finer nature as compared to those employed in the present study. He also reported similar findings for groups of baseball, soccer and basketball players.

Stroup (118) has reported findings similar to those of the present study with respect to total field of vision and athletic ability.

It was contended in the preceding review of the literature that prior studies had failed to adequately recognize the problem of high performance specificity in such entities as reaction time and movement time, with the result that low correlations were to be expected between isolated and unrelated tests of reaction time and movement time and skill level in various sports. A concerted effort was made in the present study to overcome this criticism by incorporating reaction time and movement time tests that were in many respects, outwardly at least, related to the sport in question.

Despite the apparent similarity, the results point rather strongly to the lack of any sizable relationship between the selected variables and the criterion. In fact, when the predictive value of these several variables was combined, the result was still indicative of a high degree of performance specificity.

The correlation between the ratings of the two independent hockey experts was considerably higher than was the correlation of any of the isolated variables to the criterion.

<u>Reaction Time--Movement Time Correlations</u>

Of the intercorrelations between various aspects of reaction time and movement time only one was significant (choice reaction time and choice movement time r = .44). The majority of studies to date have reported little or no correlation between these entities (29,44,49,50,51,52,73,102,115,116,135).

There are a few studies on the other hand which have reported somewhat larger reaction time-movement time correlations, namely Howell (57), who found a significant relationship (r = 0.38; N = 50) in a situation involving special motivation, Hipple (56) who reported a correlation of r = 0.31 which was significant for his group of sixty subjects, and Wilson (131) who recently obtained a significant figure of r = 0.31 (N = 50).

In addition there are, of course, two other studies, Westerlund and Tuttle (129) and Pierson (99), both of whom reported considerably larger correlations. These have been discussed elsewhere.

The present figure of r = 0.44 (r_{tt} = 0.48, with error removed) is therefore higher than those previously reported. The age range of the subjects (18 - 26 years) is not a causal factor since, with age partialled out the size of the correlation remains the same, on the other hand, this may be due to the fact that this was a selected sample of athletes and that further, the type of response situation was quite specialized. This finding in no way contradicts current neuro-motor specificity theory (54), since only 23 per cent ($.55^2$ x 100) of the individual difference variance in movement time is accounted for by individual differences in choice reaction time ability.

By far the largest portion of the individual difference variance is item specific.

Differences Between Superior and Inferior Groups on the Capacities Investigated.

No significant difference was found between the superior and inferior groups for measures of simple reaction time.

This finding is not consistent with a report by Olsen (90), who found significant differences between a group of superior athletes and a group of intermediate athletes.

Similar results are reported for studies of athletes versus non-athletes by Knapp (69), Burly (14), and Sigerseth and York (114).

Simple reaction time as used in the present study is misleading in terms of the degree of complexity involved. Studies reported in the earlier review of the literature have used this term to describe either a simple finger response, or a reaction to a simple arm or hand movement. The term simple reaction time as used here, describes the time taken to initiate a predetermined as opposed to a choice reaction, on skates, for a series of complex, coordinated body movements.

An indication of the degree of reaction time complexity may be gained from a comparison of the actual length of the latency period. The mean reaction time for this task was .390 seconds and .400 seconds for the superior and inferior groups respectively, and may be contrasted with times typically reported for extremely simple reactions, for instance, 0.217 seconds for simple hand movements (98), and 0.196 seconds for a ball grasp (49).

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Movement Time

The difference between the superior and inferior groups on simple and choice movement time was not significant. These findings are not in agreement with previous findings reported by Atwell and Elbel (2), Keller (67), Pfitsch (96) and Younger (135).

Peripheral Vision

The finding of no significant differences between the groups with respect to peripheral vision is consistent with results reported by Winogard (132), but not with findings reported by several other investigators (93,118). However, Patty (93) did find that successful basketball players were superior to unsuccessful players with respect to left peripheral vision.

Depth Perception

Similarly, binocular depth perception as a measure of visual efficiency failed to differentiate between the groups. This finding is in disagreement with a previous study reported by Clark and Warren (17) who found significant differences between athletes and non-athletes on depth perception measures. Similar findings are reported by Patty (93) for a basketball group of different ability levels.

Contrary evidence is presented by the findings of Bannister and Blackburn (3), Kestovnikov (66), Olsen (90) and Winogard (132). These all report differences in favour of the athletes as a group.

That no significant difference was found between the groups in the present study could be attributed to the possibility that neither depth perception nor peripheral vision are important

factors in athletic performance provided some degree of proficiency is present. The head is never maintained in a fixed position in a game situation. It takes only a fleeting glance to gain the necessary information as to where an object is located.

On the other hand, the tests themselves may be either specific or too limited for use in measuring the degree of importance of visual efficiency in a dynamic and changing situation such as ice hockey where one is presented with a very much different environment than that offered in performing on these static measures of visual acuity.

Difference Between Selected Trial Intervals for Reaction Time and Movement Time

It is obvious that considerable learning occurred over the first fifteen practice trials. The difference between the initial (trials 1-3) versus the final score (trials 13-15) was significant for both reaction time and movement time.

These findings are in accord with those of Henry (52) who found learning to be a significant factor in early trials of reaction time.

However, learning did not continue to occur for either the choice reaction time or movement time situations or for the simple reaction time-movement time phase of the study. This is inconsistent with Henry's (52) finding that learning occurs up to eighty trials for reaction time.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate certain underlying psychological capacities believed related to hockey playing ability. The capacities investigated were: total body reaction time and movement time, depth perception (binocular), and peripheral vision.

The subjects were twenty-eight candidates for the 1964-65 University of Alberta hockey team. They ranged in age from 18 to 26 years.

Tests of reaction time and movement time were conducted under conditions thought to be familiar to hockey players, and which simulated actual types of game responses considered important indicators of skill proficiency. All subjects were dressed in full hockey equipment. They were required to respond as quickly as possible to a visual signal by skating at top speed to either one of the three designated timing stations located a distance of fifteen feet from the starting position. Fifteen practice trials were given to each subject before the actual testing began.

A noticeable amount of improvement occurred during this period of trials. However, no continued improvement was apparent during the actual testing period of sixty trials.

The measurement of reaction time and movement time was facilitated by the use of equipment designed especially for this study. Peripheral vision was measured by means of the Perimeter,

and Depth perception was tested using the Howard-Dolman apparatus.

On the basis of the statistical analysis and within the limitations of the study, the following appear to be justified.

1. Skating speed as represented by movement time over a fifteen foot distance was positively related to hockey ability, when the latter was rated by two independent hockey experts.
2. The reaction time and movement time in a choice response situation were positively related. All other measures of reaction time and speed of body movement were independent functions and not significantly related.
3. No significant differences were found between the superior and inferior groups for any of the variables investigated.
4. There was no significant improvement in either reaction time or movement time for the group as a whole throughout the test period.

In the light of these findings, it would appear that, with the exception of simple movement time, the measures employed in this study are not good predictors of hockey ability.

Recommendations

As the present study progressed, several interesting possibilities with respect to further studies came to the attention of the author. Therefore, the following studies are recommended:

1. The development of more suitable tests of vision for athletes such as hockey players who participate in dynamic game situations.

2. Further studies designed to uncover some of the factors, inherent in hockey ability in particular, and athletic ability in general.
3. A study of the effect of dominance on the ability of hockey players to move in either direction, right or left.
4. A study of the role of kinesthetic acuity in hockey ability.
5. A study of hand-eye and foot-eye reaction times in relation to goal tending ability.
6. A study similar in scope to the present one which would serve to cross-validate the findings of this study.

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APPENDIX A

STATISTICAL TREATMENT

Statistical Treatment

Reliabilities. Reliability coefficients were determined using the Pearson-Product Moment-Method. The formula used was:

$$r = \frac{N \sum xy - \sum x \sum y}{\sqrt{[N\sum X^2 - (\sum X)^2][N\sum Y^2 - (\sum Y)^2]}} \qquad (30{:}92)$$

where: N = the number of subjects

X = the odd numbered trial scores

Y = the even numbered trial scores

$\sum$ = summation sign.

The reliability coefficients were corrected for full test length using the Spearman-Brown Prophecy formula.

$$r_{tt} = \frac{2.r_{hh}}{1 + r_{hh}} \qquad (30{:}280)$$

Correlation Coefficients. The correlation coefficients between the criterion and the independent variables were determined by using the Pearson-Product Moment Correlation Method. The formula appears above.

The correlation between the ratings of the two hockey experts was also determined by the Pearson-Product Moment Method. As a further check on this relationship, the Spearman Coefficient of rank correlation method was used. The formula used was:

$$p = \frac{6 \quad d^2}{N(n^2 - 1)} \qquad (30{:}180)$$

Multiple Regression Analysis. The multiple regression analysis of the specific variables to the criterion was calculated by the Aitkin Numerical Solution (30:298)

To test the significance of the multiple correlation, the following formula was used.

$$F = \frac{R^2}{1-R^2} \quad \frac{N-k-1}{k} \qquad (30:301)$$

where:

R = multiple correlation coefficients

N = number of observations

k = number of predictors

Significance of the Difference Between the Superior and Inferior Groups.

The difference between the superior and inferior groups on all capacities measured was determined by using a t test, the formula for which was

$$t = \frac{\overline{X}_1 - \overline{X}_2}{S_{\overline{x}_1 - \overline{x}_2}} \qquad (30:143)$$

Significance of the Difference Between Selected Trial Intervals For Reaction Time and Movement Time.

To test the significance of the difference between two selected trial intervals, a t test between two means for correlated samples was used. The formula used was:

$$t = \frac{\overline{D}}{S_D} = \frac{\overline{D}}{\sqrt{S_{D/N-1}}} \qquad (30:138)$$

APPENDIX B

SAMPLE DATA SHEETS

REACTION TIME - MOVEMENT TIME

TEST

AGE ____________
HEIGHT ________
NAME______________________ WEIGHT ________

		REACTION TIME				MOVEMENT TIME			
TRIAL		LEFT	FORW'D	RIGHT	MEAN	LEFT	FORW'D	RIGHT	MEAN
P	1								
R	2								
A	3								
C	4								
T	5								
I									
C									
E									
	1								
C	2								
H	3								
O	4								
I	5								
C	6								
E	7								
	8								
	9								
	10								
	Mn.								
	1								
S	2								
I	3								
M	4								
P	5								
L	6								
	7								
	8								
	9								
	10								
	Mn.								

NAME______________________________ AGE__________ HEIGHT__________ WEIGHT__________

	Peripheral Vision			Depth Perception
	LEFT	RIGHT	TOTAL	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
Mn.				

APPENDIX C

RAW SCORES

MEAN RT. - MT. for Practice Trials

	REACTION TIME Trials 1-3	REACTION TIME 13-15	MOVEMENT TIME Trials 1-3	MOVEMENT TIME 13-15
B. H.	.305	.278	1.668	1.747
E. W.	.419	.384	1.697	1.656
R. J.	.668	.440	1.760	1.778
D. L.	.346	.430	1.835	1.770
H. G.	.363	.350	1.829	1.769
R. H.	.350	.429	1.851	1.716
E. G.	.514	.340	1.804	1.586
S. B.	.345	.367	1.731	1.761
G. B.	.498	.450	1.764	1.705
D. W.	.412	.418	1.769	1.720
G. S.	.534	.285	1.853	1.698
J. M.	.347	.371	1.697	1.644
H. T.	.337	.403	1.853	1.760
D. Z.	.635	.425	1.795	1.839
R. C.	.633	.485	1.827	1.708
G. C.	.382	.356	1.703	1.705
B. B.	.769	.382	1.871	1.823
W. L.	.511	.430	1.671	1.670
D. Z.	.604	.380	1.946	1.817
B. H.	.944	.489	1.919	1.814
K. Z.	.532	.602	1.810	1.926
E. M.	.325	.431	1.772	1.747
D. B.	.534	.325	1.812	1.826
P. T.	.431	.386	1.810	1.695
J. E.	.748	.446	1.849	1.784
K. G.	.424	.518	1.974	1.804
G. W.	.479	.324	1.750	1.748
B. G.	.409	.434	1.738	1.731

[illegible]

MEAN RT. MT. for Choice Response

	REACTION TIME		MOVEMENT TIME	
	Trials 16-18	43-45	Trials 16-18	43-45
B. H.	.181	.371	1.690	1.749
E. W.	.323	.397	1.687	1.686
R. J.	.330	.483	1.754	1.753
D. L.	.411	.401	1.711	1.837
H. G.	.383	.342	1.808	1.785
R. H.	.365	.498	1.685	1.792
E. G.	.368	.387	1.628	1.603
S. B.	.257	.477	1.739	1.832
G. B.	.340	.402	1.730	1.730
D. W.	.594	.362	1.805	1.747
G. S.	.555	.416	1.704	1.780
J. M.	.342	.439	1.695	1.726
H. T.	.393	.382	1.883	1.888
D. Z.	.469	.464	1.866	1.805
R. C.	.315	.258	1.697	1.749
G. C.	.328	.387	1.644	1.743
B. B.	.700	.320	1.808	1.780
W. L.	.287	.438	1.642	1.757
D. Z.	.726	.480	1.920	1.937
B. H.	.455	.421	1.920	1.881
K. Z.	.657	.621	1.829	1.859
E. M.	.598	.455	1.803	1.768
D. B.	.310	.299	1.866	1.898
P. T.	.533	.440	1.790	1.836
J. E.	.604	.555	1.776	1.806
K. G.	.523	.396	1.867	1.834
G. W.	.333	.374	1.773	1.695
B. G.	.299	.632	1.723	1.725

MEAN RT. - MT. for Simple Response

	REACTION TIME Trials 46-48	73-75	MOVEMENT TIME Trials 46-48	73-75
B. H.	.331	.396	1.638	1.633
E. W.	.402	.365	1.662	1.637
R. J.	.563	.401	1.646	1.641
D. L.	.369	.318	1.709	1.663
H. G.	.368	.260	1.644	1.685
R. H.	.412	.564	1.696	1.674
E. G.	.285	.290	1.500	1.540
S. B.	.280	.359	1.689	1.748
G. B.	.524	.481	1.659	1.599
D. W.	.335	.242	1.651	1.675
G. S.	.385	.556	1.647	1.671
J. M.	.389	.314	1.673	1.664
H. T.	.454	.307	1.705	1.744
D. Z.	.521	.274	1.785	1.781
R. C.	.488	.536	1.690	1.808
G. C.	.320	.426	1.641	1.714
B. B.	.363	.247	1.716	1.767
W. L.	.294	.288	1.688	1.679
D. Z.	.475	.472	1.785	1.860
B. H.	.402	.464	1.863	1.761
K. Z.	.498	.311	1.836	1.825
E. M.	.633	.522	1.782	1.718
D. B.	.325	.352	1.719	1.757
P. T.	.418	.327	1.647	1.681
J. E.	.532	.729	1.747	1.793
K. G.	.573	.383	1.763	1.764
G. W.	.317	.304	1.637	1.708
B. G.	.296	.311	1.665	1.649

REACTION - TIME -- SUPERIOR HOCKEY GROUP

		LEFT	FORWARD	RIGHT	TOTAL MEAN
B. H.	Offensive	.490	.307	.368	.388
	Defensive	.431	.294	.294	.340
E. W.	Offensive	.426	.343	.336	.368
	Defensive	.371	.359	.396	.375
R. J.	Offensive	.358	.527	.346	.410
	Defensive	.402	.404	.456	.421
D. L.	Offensive	.375	.388	.333	.365
	Defensive	.386	.400	.406	.395
H. G.	Offensive	.333	.344	.351	.343
	Defensive	.302	.472	.395	.390
R. H.	Offensive	.465	.381	.407	.418
	Defensive	.525	.442	.415	.461
E. G.	Offensive	.393	.294	.422	.370
	Defensive	.366	.384	.470	.407
S. B.	Offensive	.374	.276	.271	.307
	Defensive	.357	.464	.326	.382
G. B.	Offensive	.527	.352	.468	.449
	Defensive	.394	.392	.406	.397
D. W.	Offensive	.424	.365	.435	.367
	Defensive	.405	.534	.313	.458
G. S.	Offensive	.608	.519	.462	.530
	Defensive	.507	.709	.507	.545
J. M.	Offensive	.404	.412	.351	.389
	Defensive	.442	.503	.448	.464
H. T.	Offensive	.373	.409	.323	.368
	Defensive	.430	.406	.354	.396
D. Z.	Offensive	.437	.357	.373	.389
	Defensive	.383	.494	.451	.443

REACTION - TIME -- INFERIOR HOCKEY GROUP

		LEFT	FORWARD	RIGHT	TOTAL MEAN
R. C.	Offensive	.353	.405	.412	.390
	Defensive	.444	.599	.427	.440
G. C.	Offensive	.300	.276	.259	.278
	Defensive	.310	.341	.352	.334
B. B.	Offensive	.320	.330	.353	.334
	Defensive	.464	.484	.476	.475
W. L.	Offensive	.359	.346	.293	.333
	Defensive	.416	.310	.311	.346
D. Z.	Offensive	.445	.508	.469	.474
	Defensive	.472	.625	.580	.559
B. H.	Offensive	.547	.379	.429	.452
	Defensive	.471	.578	.482	.510
K. Z.	Offensive	.411	.394	.388	.388
	Defensive	.604	.737	.629	.657
E. M.	Offensive	.664	.559	.392	.538
	Defensive	.595	.499	.520	.538
D. B.	Offensive	.305	.335	.334	.325
	Defensive	.323	.357	.338	.339
P. T.	Offensive	.422	.408	.474	.435
	Defensive	.393	.397	.434	.408
J. E.	Offensive	.560	.521	.460	.508
	Defensive	.571	.676	.379	.542
K. G.	Offensive	.448	.499	.475	.474
	Defensive	.550	.474	.496	.507
G. W.	Offensive	.315	.280	.357	.317
	Defensive	.317	.307	.371	.332
B. G.	Offensive	.374	.311	.356	.347
	Defensive	.368	.539	.349	.419

MOVEMENT - TIME -- SUPERIOR HOCKEY GROUP

		MEAN LEFT	MEAN FORWARD	MEAN RIGHT	TOTAL MEAN
B. H.	Offensive	1.654	1.626	1.682	1.654
	Defensive	1.637	1.739	1.730	1.729
E. W.	Offensive	1.637	1.651	1.696	1.643
	Defensive	1.742	1.807	1.642	1.748
R. J.	Offensive	1.626	1.684	1.609	1.667
	Defensive	1.744	1.811	1.738	1.764
D. L.	Offensive	1.675	1.682	1.658	1.672
	Defensive	1.751	1.754	1.702	1.736
H. G.	Offensive	1.622	1.710	1.825	1.719
	Defensive	1.712	1.821	1.810	1.781
R. H.	Offensive	1.682	1.714	1.676	1.691
	Defensive	1.800	1.749	1.729	1.759
E. G.	Offensive	1.548	1.581	1.498	1.542
	Defensive	1.618	1.667	1.543	1.609
S. B.	Offensive	1.734	1.758	1.688	1.727
	Defensive	1.856	1.869	1.753	1.826
G. B.	Offensive	1.644	1.665	1.659	1.656
	Defensive	1.735	1.797	1.722	1.751
D. W.	Offensive	1.648	1.715	1.629	1.664
	Defensive	1.783	1.781	1.705	1.756
G. S.	Offensive	1.662	1.726	1.649	1.679
	Defensive	1.766	1.821	1.720	1.769
J. M.	Offensive	1.696	1.722	1.650	1.689
	Defensive	1.744	1.804	1.684	1.744
H. T.	Offensive	1.712	1.794	1.750	1.752
	Defensive	1.798	1.936	1.812	1.849
D. Z.	Offensive	1.746	1.823	1.793	1.787
		1.861	1.906	1.807	1.858

MOVEMENT-TIME - - INFERIOR HOCKEY GROUP

		LEFT	FORWARD	RIGHT	TOTAL MEAN
R. C.	Offensive	1.713	1.789	1.671	1.733
	Defensive	1.759	1.773	1.696	1.763
G. C.	Offensive	1.668	1.644	1.610	1.641
	Defensive	1.745	1.763	1.681	1.730
B. B.	Offensive	1.701	1.728	1.728	1.719
	Defensive	1.749	1.856	1.809	1.805
W. L.	Offensive	1.693	1.676	1.690	1.686
	Defensive	1.752	1.741	1.719	1.737
D. Z.	Offensive	1.841	1.868	1.889	1.866
	Defensive	1.868	1.954	1.919	1.914
B. H.	Offensive	1.788	1.831	1.821	1.813
	Defensive	1.903	1.931	1.867	1.900
K. Z.	Offensive	1.807	1.858	1.704	1.790
	Defensive	1.809	1.897	1.762	1.883
E. M.	Offensive	1.733	1.763	1.760	1.752
	Defensive	1.762	1.834	1.802	1.799
D. B.	Offensive	1.729	1.771	1.748	1.749
	Defensive	1.834	1.807	1.785	1.809
P. T.	Offensive	1.666	1.719	1.684	1.712
	Defensive	1.717	1.894	1.790	1.800
J. E.	Offensive	1.744	1.731	1.767	1.747
	Defensive	1.792	1.779	1.780	1.784
K. G.	Offensive	1.768	1.773	1.800	1.780
	Defensive	1.843	1.916	1.898	1.780
G. W.	Offensive	1.631	1.760	1.661	1.684
	Defensive	1.668	1.800	1.715	1.728
B. G.	Offensive	1.669	1.651	1.685	1.668
	Defensive	1.722	1.765	1.709	1.732

DEPTH PERCEPTION - PERIPHERAL VISION - SUPERIOR HOCKEY GROUP

	MEAN LEFT	MEAN RIGHT	MEAN TOTAL	MEAN DEPTH PERCEPTION
B. H.	84.1°	83.3°	167.4°	1.08 cm.
E. W.	89.3°	86.9°	176.2°	1.30 cm.
R. J.	87.1°	86.4°	173.5°	4.19 cm.
D. L.	88.2°	85.7°	173.8°	1.34 cm.
H. G.	88.4°	88.9°	177.3°	2.53 cm.
R. H.	87.8°	87.8°	175.6°	.78 cm.
E. G.	86.9°	85.9°	172.8°	1.54 cm.
S. B.	86.7°	84.5°	171.2°	1.82 cm.
G. B.	87.1°	86.7°	173.8°	1.64 cm.
D. W.	88.4°	86.6°	175.0°	4.53 cm.
G. S.	87.3°	87.6°	174.9°	1.87 cm.
J. M.	87.9°	88.9°	176.8°	1.04 cm.
H. T.	89.0°	88.3°	177.3°	.76 cm.
D. Z.	81.9°	81.9°	163.8°	2.40 cm.

DEPTH PERCEPTION - PERIPHERAL VISION -- INFERIOR HOCKEY GROUP

	MEAN LEFT	MEAN RIGHT	MEAN TOTAL	MEAN DEPTH PERCEPTION
R. C.	88.7°	89.8°	178.5°	1.13 cm.
G. C.	88.9°	88.9°	177.8°	.80 cm.
B. B.	88.6°	84.2°	172.8°	.87 cm.
W. L.	89.2°	89.2°	178.4°	1.85 cm.
D. Z.	83.2°	81.4°	164.6°	4.07 cm.
B. H.	87.5°	82.6°	170.1°	3.08 cm.
K. Z.	89.5°	89.6°	179.1°	.68 cm.
E. M.	88.5°	86.5°	175.0°	.53 cm.
D. B.	87.0°	88.3°	175.3°	2.34 cm.
P. T.	89.2°	88.3°	177.5°	1.56 cm.
J. E.	90.0°	87.7°	177.7°	.41 cm.
K. G.	88.5°	88.5°	177.0°	1.02 cm.
G. W.	80.0°	88.2°	178.2°	.60 cm.
B. G.	88.6°	86.1°	174.7°	1.73 cm.